



IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

Amendment 3: Precision Time Protocol (PTP) Enhancements for Best Master Clock Algorithm (BMCA) Mechanisms

IEEE Instrumentation and Measurement Society

Developed by the
Technical Committee on Sensor Technology (TC-9)

IEEE Std 1588a™-2023
(Amendment to IEEE Std 1588™-2019
as amended by IEEE Std 1588b™-2022 and
IEEE Std 802.1588g™-2022)

STANDARDS

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Abstract: Updates to information and messages for the Enhanced Accuracy TLV are provided in this amendment to IEEE 1588-2019. This amendment also clarifies the operation of the best master clock algorithm (BMCA), provides a new annex about the default BMCA, corrects errors in the text, and clarifies unclear passages.

Keywords: Best Master Clock, BMCA, Enhanced Accuracy, IEEE 1588a™, TLV

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Introduction

This introduction is not part of IEEE Std 1588a-2023, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems—Amendment 3: Precision Time Protocol (PTP) Enhancements for Best Master Clock Algorithm (BMCA) Mechanisms.

IEEE Std 1588-2019 defines the Precision Time Protocol and mappings for several network transport media technologies, for example Ethernet. IEEE Std 1588a updates the operation of the Enhanced Accuracy TLV.

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NOTE—The editing instructions contained in this **amendment** define how to merge the material contained therein into the existing base standard and its amendments to form the comprehensive standard.⁶

The editing instructions are shown in ***bold italic***. Four editing instructions are used: change, delete, insert, and replace. ***Change*** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~striketrough~~ (to remove old material) and underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new one. Editing instructions, change markings, and this NOTE will not be carried over into future editions because the changes will be incorporated into the base standard.

⁶ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

3. Definitions, acronyms, and abbreviations

3.2 Acronyms and abbreviations

Insert the following acronym into 3.2, maintaining alphabetical order:

GM Grandmaster PTP Instance

7. Characterization of PTP characterization

7.7 PTP timing characterization

7.7.2 PTP message transmission intervals

7.7.2.2 Announce message transmission interval

Change 7.7.2.2 (the second paragraph) and NOTE 2 as follows:

The portDS.logAnnounceInterval shall specify the mean time interval between successive Announce messages, that is, the announceInterval (see 9.5.8).

The portDS.logAnnounceInterval should be uniform throughout a domain, unless the optional feature of 17.8 is used. The behavior of domains in which this is not so is outside the scope of this standard, unless the optional feature of 17.8 is used.

NOTE 1—The value of portDS.logAnnounceInterval is a compromise between the desired responsiveness to changes in the PTP Network in determining the master-slave hierarchy in a domain and the communication and computation load imposed by transmission of these messages.

NOTE 2—It might be desirable for the portDS.logAnnounceInterval to be different in regions of different communication technologies, for example, wired and wireless technologies. Unless the optional feature of 17.8 is used, systems where the portDS.logAnnounceInterval varies from region to region need to adjust the value of the portDS.announceReceiptTimeout on all PTP Ports to ensure that timeouts do not occur as a result of the differences in the announceIntervals. Even with this precaution, reconfiguration of the entire PTP Network will usually take longer than with comparable uniform intervals.

7.7.3 PTP timeouts

7.7.3.1 Port DS.announceReceiptTimeout

Change 7.7.3.1 (third paragraph) and add two new paragraphs as follows:

The value of portDS.announceReceiptTimeout shall specify the number of announceIntervals that must pass without receipt of an Announce message before the occurrence of the event ANNOUNCE_RECEIPT_TIMEOUT_EXPIRES (see 9.2.6.12). The range shall be 2 to 255 subject to further restrictions of the applicable PTP Profile. Although 2 is permissible, normally the value should be at least 3.

NOTE 1—A value of 2 is permitted but is not recommended except in carefully controlled environments where more rapid reaction to missed Announce messages is needed and the number of missed messages is very low.

~~The product $(\text{portDS.announceReceiptTimeout}) \times 2^{\text{portDS.logAnnounceInterval}}$ should be uniform throughout a domain. The behavior of domains for which this is not the case is outside the scope of this standard. The product $(\text{portDS.announceReceiptTimeout}) \times \text{announceInterval}$ should be uniform throughout a domain when the optional feature of 17.8 is not used; in this case the value of announceInterval is $2^{\text{portDS.logAnnounceInterval}}$ (see 7.7.2.2 and 8.2.15.4.1).~~

If the optional feature of 17.8 is used, the value of announceInterval is derived from the $\text{logMessageInterval}$ field of the most recently received qualified Announce message, unless the Announce message is unicast and unicast negotiation is used, in which case the announceInterval is derived from the $\text{logInterMessagePeriod}$ field of the GRANT UNICAST TRANSMISSION TLV that granted this unicast session.

The behavior of domains for which the product $(\text{portDS.announceReceiptTimeout}) \times \text{announceInterval}$ is not uniform throughout the domain is outside the scope of this standard unless the optional feature of 17.8 is used.

8. PTP data sets

8.1 General specifications for data set members

8.1.4 Use of data sets for managements

8.1.4.2 Organization within a PTP Node

Change the list in 8.1.4.2, and renumber subsequent list items as follows:

The following hierarchy summarizes the managed data sets within a PTP Node:

- a) instanceList []
 - 1) *defaultDS*
 - 2) *currentDS*
 - 3) *parentDS*
 - 4) *timePropertiesDS*
 - 5) *descriptionDS*
 - 6) *faultLogDS*
 - 7) *nonVolatileStorageDS*
 - 8) *pathTraceDS*
 - 9) *alternateTimescaleOffsetsDS*
 - 10) *holdoverUpgradeDS*
 - 11) *grandmasterClusterDS*
 - 12) *acceptableMasterTableDS*
 - 13) *performanceMonitoringDS*
 - 14) *enhancedSynchronizationAccuracyMetricsDS*
 - 14)15) *adaptiveReceiptTimeoutDS*
 - 15)16) portList []
 - i) *portDS*
 - ii) *timestampCorrectionPortDS*
 - iii) *asymmetryCorrectionPortDS*
 - iv) *descriptionPortDS*

- v) *unicastNegotiationPortDS*
- vi) *alternateMasterPortDS*
- vii) *unicastDiscoveryPortDS*
- viii) *acceptableMasterPortDS*
- ix) *L1SyncBasicPortDS*
- x) *L1SyncOptParamsPortDS*
- xi) *communicationCapabilitiesPortDS*
- xii) *performanceMonitoringPortDS*
- ~~xiii) *commonServicesPortDS*~~
- ~~xiii) *slaveMonitoringPortDS*~~
- ~~xiv) *externalPortConfigurationPortDS*~~
- ~~xiv) *commonServicesPortDS*~~
- ~~xv) *slaveMonitoringPortDS*~~
- ~~xvi) *adaptiveReceiptTimeoutPortDS*~~
- b) *transparentClockDefaultDS*
- c) *transparentClockPortList[]*
- 1) *transparentClockPortDS*
- d) *commonServices*
 - 1) *commonMeanLinkDelayService*
 - i) *cmlDsDefaultDS*
 - ii) *cmlDsLinkPortList[]*
 - ⚭ A) *cmlDsLinkPortDS*
 - ⚭ B) *cmlDsTimestampCorrectionLinkPortDS*
 - ⚭ C) *cmlDsAsymmetryCorrectionLinkPortDS*
 - ⚭ D) *cmlDsPerformanceMonitoringLinkPortDS*

8.2 Data sets for PTP instances

Insert the following new subclause 8.2.15, and renumber subsequent subclauses as necessary:

8.2.15 adaptiveReceiptTimeoutDS

This data set provides management access to the adaptiveReceiptTimeoutDS of the optional feature for computation of <announceReceiptTimeoutInterval> and FOREIGN_MASTER_TIME_WINDOW using the received logAnnounceInterval (see 17.8). The adaptiveReceiptTimeoutDS is specified in 17.8.7.

Insert the following new subclause 8.2.31, and renumber subsequent subclauses as necessary:

This data set provides management access to the adaptiveReceiptTimeoutPortDS of the optional feature for computation of <announceReceiptTimeoutInterval> and FOREIGN_MASTER_TIME_WINDOW using the received logAnnounceInterval (see 17.8). The adaptiveReceiptTimeoutPortDS is specified in 17.8.8.

9. PTP for Ordinary Clocks and Boundary Clocks

9.2 State protocol

9.2.6 Events initiating PTP state transitions

9.2.6.12 ANNOUNCE_RECEIPT_TIMEOUT_EXPIRES

Change 9.2.6.12 as follows:

Each protocol engine shall support a timeout mechanism defining the `<announceReceiptTimeoutInterval>`. The value of `<announceReceiptTimeoutInterval>` shall be with the value of `portDS.announceReceiptTimeout` multiplied by the `announceInterval` (see 7.7.3.1), unless the optional feature of 17.8 is used.

If the optional feature of 17.8 is not used, the ANNOUNCE_RECEIPT_TIMEOUT_EXPIRES event occurs at the expiration of this timeout plus a random number uniformly distributed in the range (0,1) `announceIntervals`.

This timeout mechanism for a PTP Port shall start or be restarted when any of the following apply:

- a) For a PTP Port in the UNCALIBRATED or SLAVE states, when an Announce message is received from the Parent PTP Instance as indicated by the `parentDS.parentPortIdentity`;
- b) At the expiration of the current `<announceReceiptTimeoutInterval>` unless otherwise specified in Clause 9;
- c) When entering the LISTENING, UNCALIBRATED, SLAVE, or PASSIVE state;
- d) For a PTP Port in the PASSIVE state when an Announce message is received from the PTP Instance that transmitted the Announce message that caused the PTP Port to be in the PASSIVE state, as indicated by a comparison of the `sourcePortIdentity` fields of the respective messages.

This timeout mechanism for a PTP Port shall be stopped and not restarted when entering the INITIALIZING, PRE_MASTER, FAULTY, DISABLED, or MASTER states.

In addition to the state changes of Figure 30 and Figure 31, PTP Ports in the LISTENING, PASSIVE, UNCALIBRATED, or SLAVE states when the ANNOUNCE_RECEIPT_TIMEOUT_EXPIRES event occurs shall update data sets prior to entering the MASTER state as follows:

- For an Ordinary Clock, update the PTP Port's data sets to the MASTER state configuration (see 9.3.5), as specified for decision M4M2.
- For a Boundary Clock with no other PTP Port in the SLAVE state, update the PTP Port's data sets to the MASTER state configuration (see 9.3.5), as specified for decision M1.
- For a Boundary Clock with a different PTP Port in the SLAVE state, update the PTP Port's data sets to the MASTER state configuration (see 9.3.5) as specified for decision M3.

9.3 Best master clock algorithms

9.3.2 Best master clock algorithm

9.3.2.3 Computation of $E_{r_{best}}$

Change 9.3.2.3, item b and add 2 notes as follows:

b) Include at least two qualified Announce messages at port “r” from each considered ~~a~~ foreign master if such messages exist. In this case, “r” shall delete all such records that were considered from its implementation-specific <foreignMasterList> (see 9.3.2.4) ~~all such records that were considered~~, but not selected, as $E_{r_{best}}$.

NOTE 1—It is important that item b) above be observed to ensure that all foreign masters communicating with port “r” will eventually be considered in the computation of $E_{r_{best}}$, regardless of the implementation-specific size of the <foreignMasterList>.

NOTE 2—If all qualified Announce messages received on PTP Port “r” during the Announce interval were considered, then only the Announce message selected as $E_{r_{best}}$ will be saved in the <foreignMasterList>. After the computation of $E_{r_{best}}$, if n qualified Announce messages received on PTP Port “r” were not considered, and the capacity of foreign master records is sufficient, then n+1 Announce messages will be saved in the <foreignMasterList>

NOTE 3—If the option of 17.7 specifies that the foreign master function is not to be used, then there will never be Announce messages designated as a foreign master.

9.3.2.4 <foreignMasterList> specifications

9.3.2.4.5 FOREIGN_MASTER_TIME_WINDOW and FOREIGN_MASTER_THRESHOLD

Change the list in 9.3.2.4.5 as follows:

The values of these two attributes determine the criteria for accepting an Announce message from a previously silent PTP Instance for consideration in the operation of the best master clock algorithm. The values of these attributes shall be:

- FOREIGN_MASTER_TIME_WINDOW: 4 announceIntervals, where announceInterval is $2^{\text{portDS.logAnnounceInterval}}$ if the optional feature of 17.8 is not used (see 7.7.2.2 and 7.7.3.1)
- FOREIGN_MASTER_THRESHOLD: 2 Announce messages received within the FOREIGN_MASTER_TIME_WINDOW

NOTE—The option of 17.7 permits not using the <foreignMasterList>. Implementations can accomplish this by either not implementing the functions of 9.3.2.4 or by setting the value of the FOREIGN_MASTER_THRESHOLD to 0.

9.3.2.4.6 Size of <foreignMasterList>

Change 9.3.2.4.6 as follows:

The implementation-specific <foreignMasterList> shall have a minimum capacity of five foreign master records in the list to allow different foreign masters to be considered for $E_{r_{best}}$ selection of port “r”.